The condition of the surface layer of the manufactured workpiece is one of the most important engineering parameters. In many cases it is responsible for the length and quality of its work and cooperation with other elements. An important parameter of the surface layer, apart from its state of structure and distribution of microhardness, is the state of residual stresses remaining after finishing treatments. Residual stresses are stresses that remain in the unloaded material after the occurrence of different types of processes. Both the magnitude and the spatial distribution of residual stresses play key roles in the fatigue response of solids, stress corrosion, and they are important for manufacturing process of all products. The residual stresses superimposed by the external loads can be destructive or beneficial for the component. For example, the tensile strength of a surface layer is improved by machining in which a compressive residual stress is created. The same type of stress increases fatigue and fracture resistance and minimises the spalling effect of the coating. The contrary sort of stress, the tensile internal stress can accelerate the growth of crack and cause the coating to fail when the external loads are superimposed.

Diffraction methods are often used to measure the elastic deformations of a crystal lattice based on the displacement of the diffraction peak. In a standard measurement, the stresses are determined by the interplanar distances measured in different directions relative to the sample. This method changes the direction of the scattering vector (along which the interplanar distance is measured) in relation to the sample and determines the position of the diffraction peak for one hcl reflex. However, this method is not recommended for the analysis of stress states changing into the depth of the sample because the depth of X-rays penetration changes during the measurement. In order to measure the stress at a constant depth, the geometry of the constant angle of incidence can be used (in the English literature the name: grazing incidence X-ray diffraction, abbreviated GIXD). This method allows to perform non-destructive stress analysis for various depths (fractions of a dozen or even several dozen or even several dozen meters). The GIXD method is based on asymmetrical diffraction for small and constant incidence angles (defined as the angle between the incident beam and the surface of the specimen). In this case the depth penetration of X-ray radiation depends mainly on the incident beam path and does not change much when we change the orientation of the scattered beam (so the volume from which the stress information comes is constant).

In this project the interplanar spacings will be measured for a small and constant incidence angle α and for different *hkl* reflections corresponding to different orientations of the scattering vector (method called MGIXD – multireflection grazing incidence X-ray diffraction).

For measurements the laboratory X-ray diffractometer with Göbel mirror (or X-ray lens) in incident beam optic will be used. The ranges of application of MGIXD method will be studied in order to determine accuracy and possible depths for which the stresses can be measured. The advantage of our analysis is that also the in-depth variation of stress free lattice parameter a_o and what is more *c/a* ratio can be determined. In interpretation of the experimental results we account for the stresses present in the sample. It should be underlined that such structural characteristics cannot be obtained when the measurements are performed only for one *hkl* reflection.

In the project following polycrystalline materials will be investigated: austenitic stainless steel, Ni, Cu, Al, Ti, Mg and deposited layers: tungsten, Cu, Ni, Ag, Au, Cr, Cu. These materials were chosen due to their diversity properties and their widespread use in industry. Stress measurements in the above mentioned layered materials will be carried out during uniaxial tensile testing. For this purpose, a miniature tensile machine will be installed inside the diffractometer. The specimen will be subjected to a single-axis force within the elastic range and at several pre-set force values, both substrate and layer stresses will be measured. Simultaneously, other material properties (hardness and microstructure) and topography (using profilometer and AFM) of the surface will be controlled. The conditions of processes will be optimized in order to produce desired distribution of the stresses and microstructure in the studied coatings. It is also planned to produce samples with controlled residual stresses in the layer. For this purpose, a miniature machine will be developed to enable the pre-tensioning to be carried out during the deposition process. The results of in situ measurements will also be verified by finite element calculations. The FEM model will be based on data from a profilometer or AFM microscope. The stresses in the substrate material and the applied layer will be analysed. The results of FEM calculations will be confronted with experimental data.

In conclusion, it should be noted that the advantage of the MGIXD method is the possibility of simultaneous measurement of stress distribution and determination of in-depth variation of a_o and *c/a* structural parameters as well as the analysis of diffraction peak profile. The latter results, not possible to obtain using other methods are very important and they can be used to optimize the properties of the surface layers and coatings.